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Numerical Analysis of Microwave Detection of Breast Tumours using Synthetic Focussing Techniques

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Overview

- Breast cancer facts
- The microwave imaging technique used at Bristol.
- Validation using FDTD, and skin clutter mitigation.
- Practical measurements (produced since paper submission)
- Future work
- Conclusions

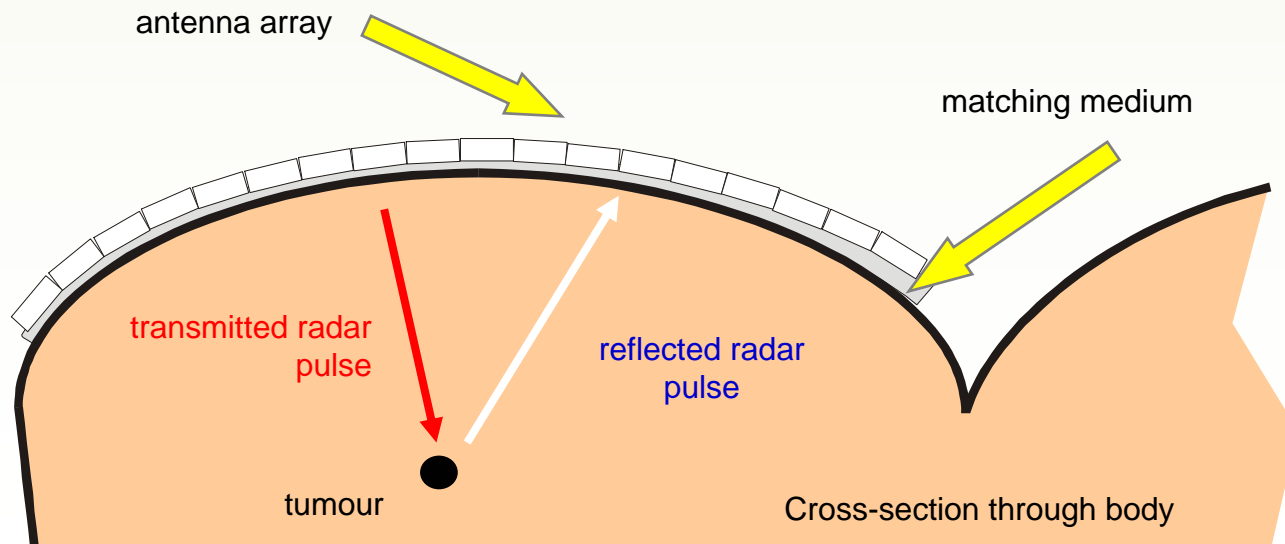


Breast Cancer Facts

- Breast cancer is one of the most common cancers in women
- A woman will be diagnosed with breast cancer every 3 minutes in US alone.
- Breast Imaging Techniques
 - **X-ray Mammography**
 - Relatively high false negative rate: 4%- 34%
 - High false positive rate : 70%
 - Poor contrast resolution
 - Ionising
 - Uncomfortable
 - **Ultrasound Methods**
 - Small tumours have been detected
 - Poor spatial resolution
 - **Contrast Enhanced MRI**
 - Too costly for mass screening purposes

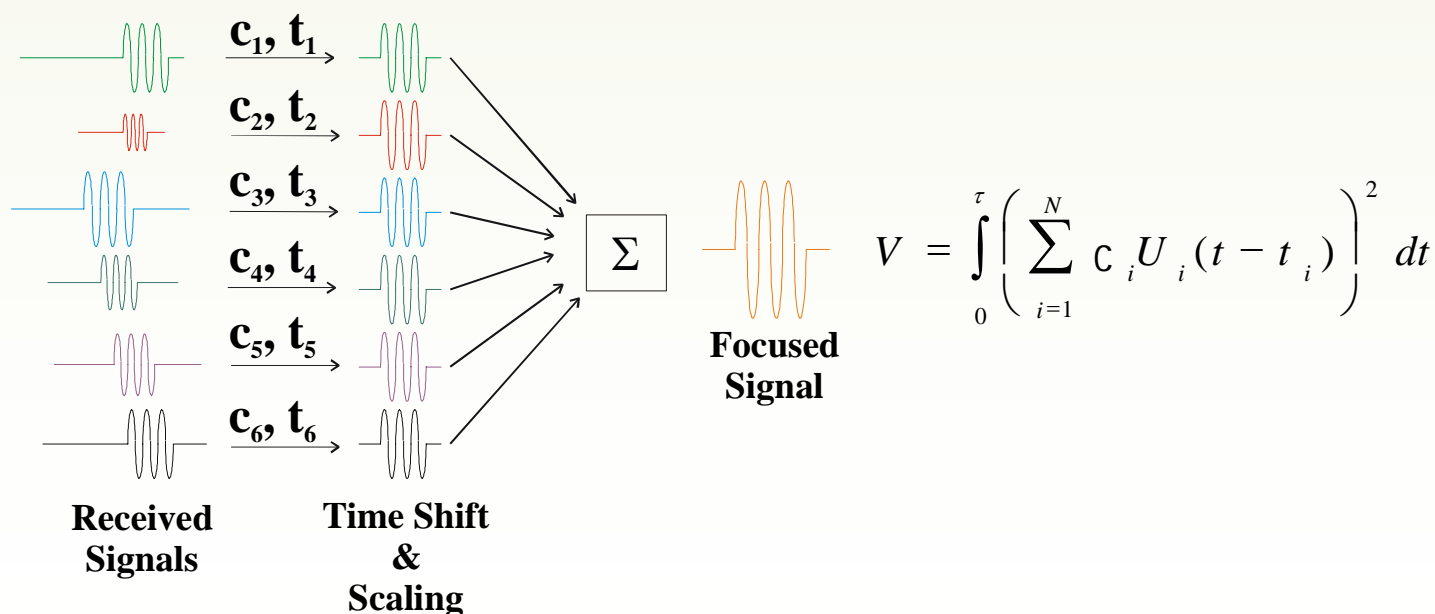
Microwave Detection

- Clutter is a major problem.
- Especially skin reflection (also mutuels, tissue inhomogeneity, chest wall).
- A radar technique investigated in the field of Landmine Detection at Bristol gives good clutter rejection by combining **all possible TX/RX pairs in an antenna array**.



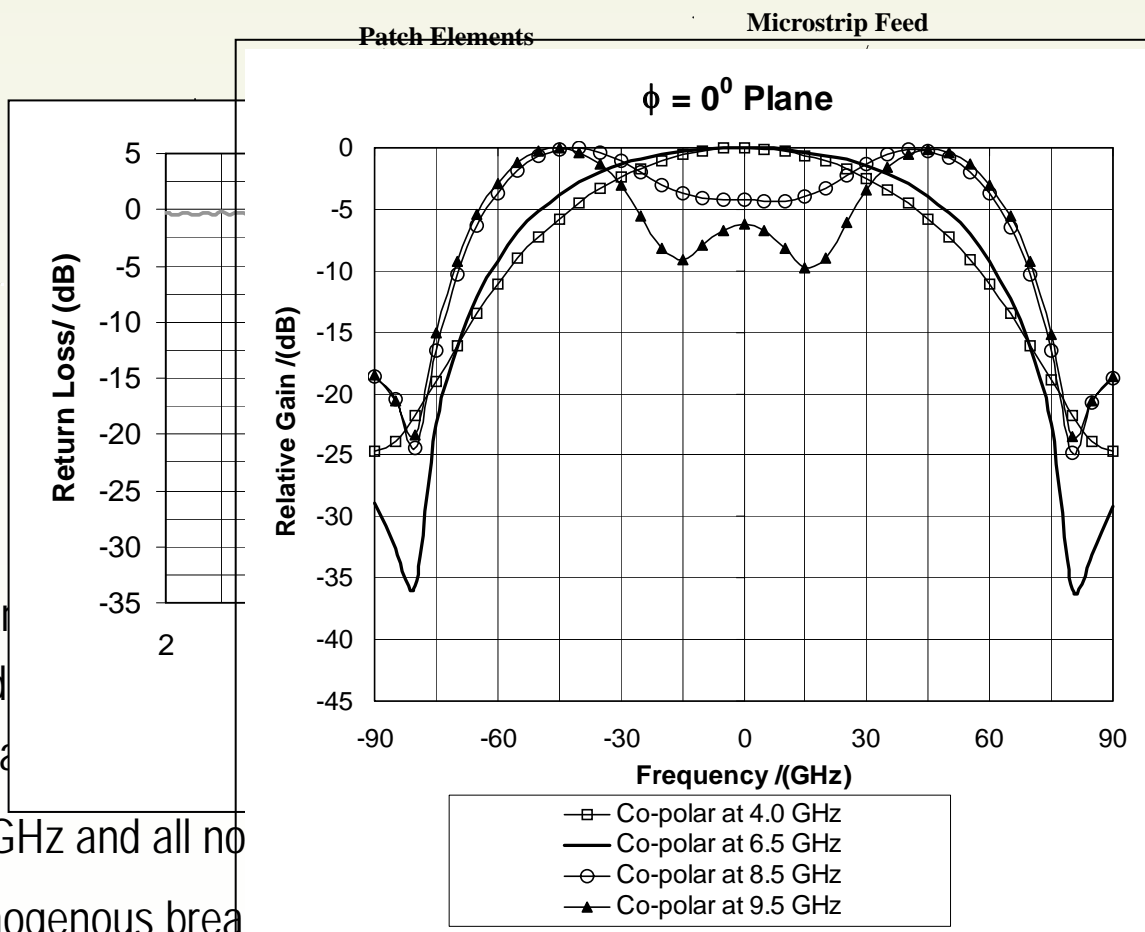
Microwave Imaging

- Real Aperture Synthetically Organised Radar
 - Number of paths is $N(N-1)/2$ (very large)





FDTD Model

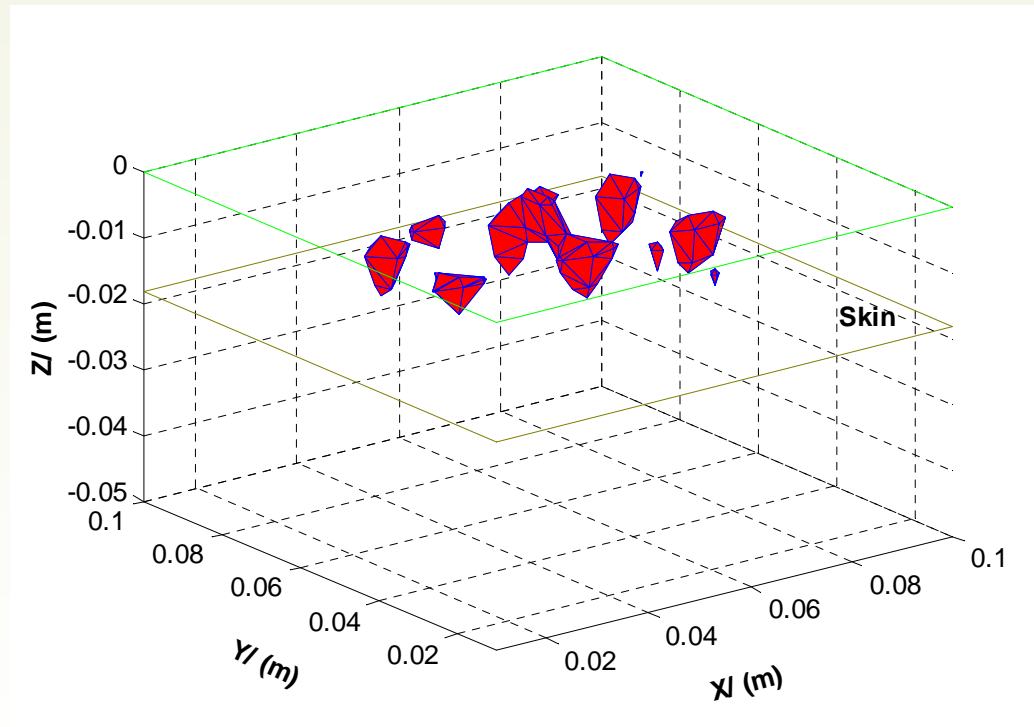


- 16 Antennas
- Yield
- The antenna array is fed by a two-cycle pulse at 6.5 GHz and all no
- Homogenous bre

- Tumour $\epsilon_r = 50 + j1.02$
- Skin $\epsilon_r = 40 + j5.86$

two-cycle pulse at

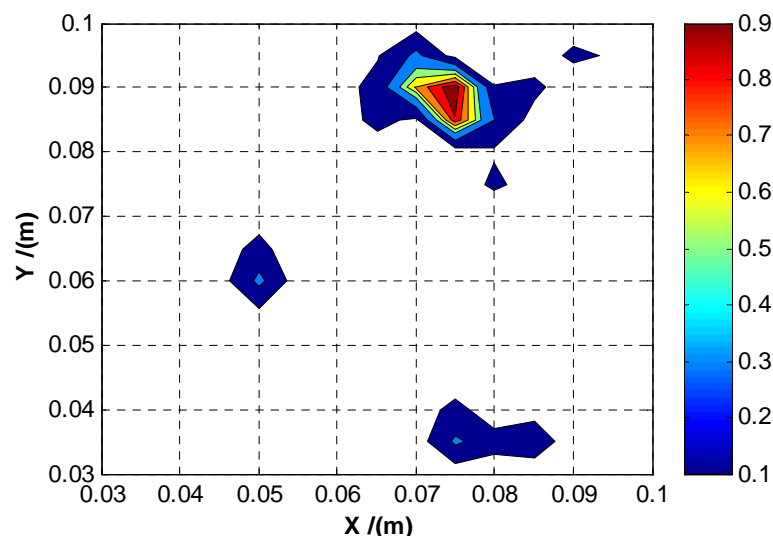
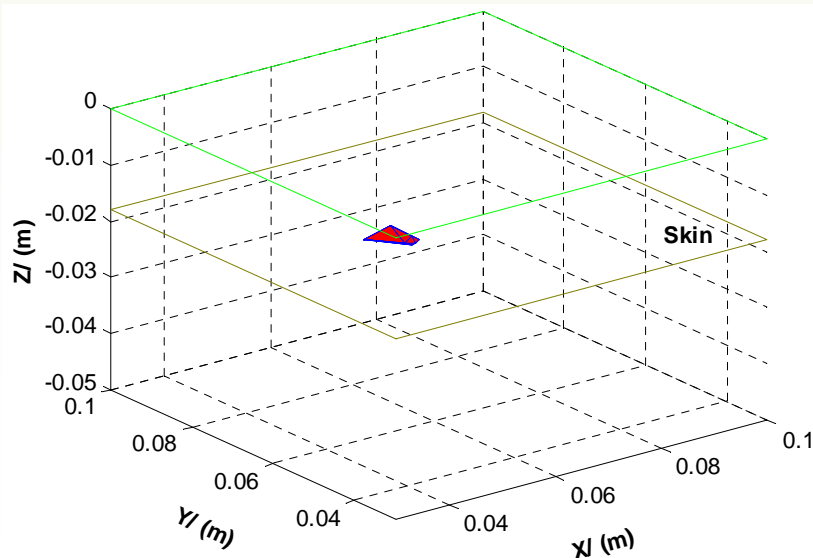
FDTD Model Results (1)



- Reflection from skin dominates the results.
- 2mm tumour is obscured.

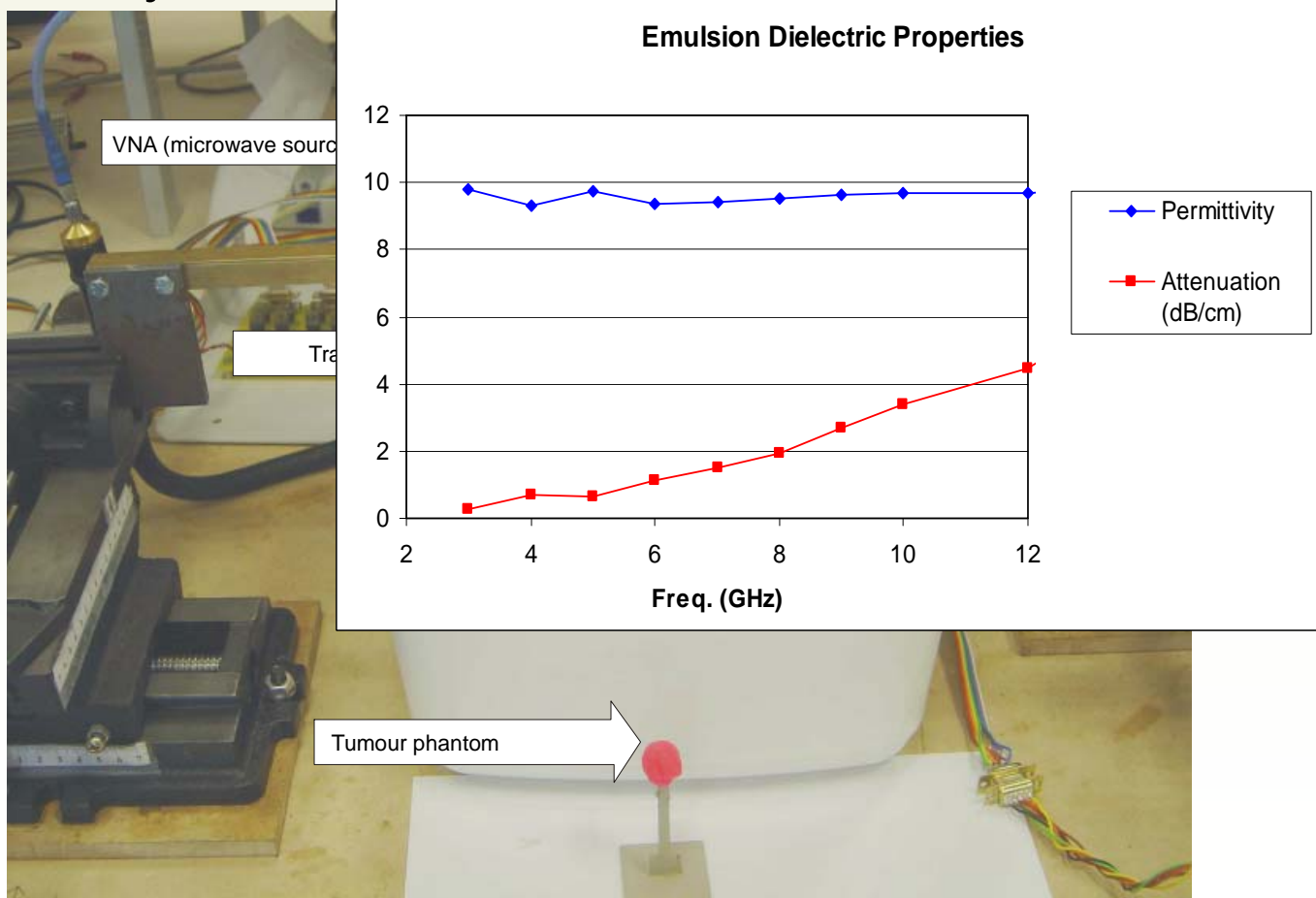
FDTD Model Results (2)

- If the array is offset slightly from the initial position, the reflection from skin stays largely the same, but the response from the tumour is displaced.
- On subtraction this gives a negative and positive image.
- This provides a simple mechanism for mitigating surface reflection:



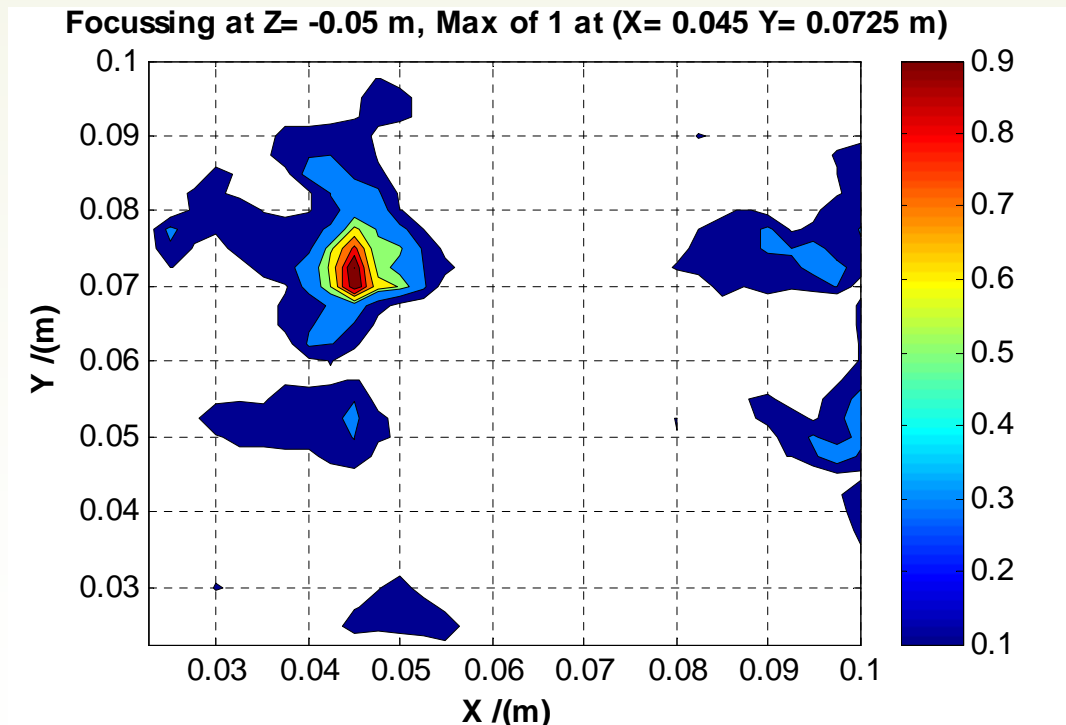
Practical Set-Up

- Entire array simulated using mechanically driven pair of antennas.



Practical Results

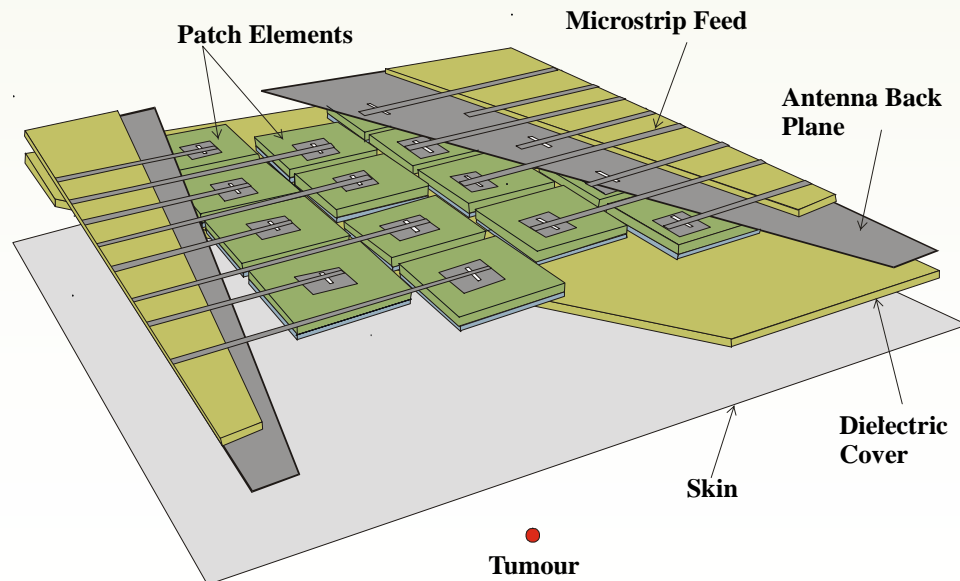
- Skin effect mitigated using the offset technique described here.



- 6mm tumour (position $x = 46$ mm, $y = 69$ mm, $z = -45$ mm).

Future Work

- Alternative skin clutter suppression techniques have been developed.
- The fully-populated antenna array (designed using FDTD) arrives on Thursday.
- RF switching and switch-driving system is under construction.





Conclusions

- Breast cancer detection using microwaves would be a very attractive, freely repeatable, and low-cost alternative, or adjunct, to Mammography.
- Detailed, realistic, FDTD models have been invaluable in designing antenna elements and validating the focussing and clutter-rejection techniques.
- A simple array-offset scheme gives good reduction in skin clutter and is practically feasible.
- Other skin clutter rejection techniques arise from the identification of similar paths with the array.
- Practical work with realistic phantoms has yielded results in line with expectations from FDTD.
- A fully-populated array is in the final stages of construction.